Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

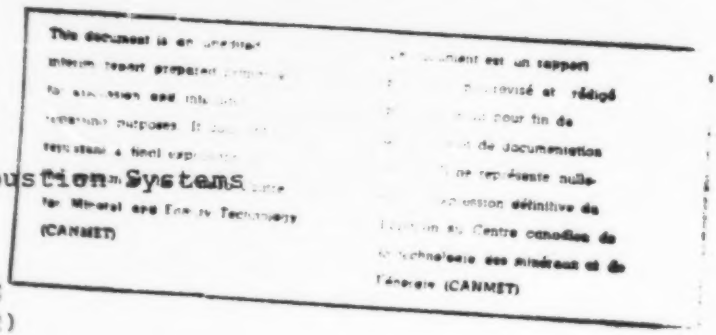
CANMET
Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

SCANNING ELECTRON MICROSCOPIC EXAMINATION OF CHATHAM CIRCULATING FLUIDIZED BED COMBUSTOR ASHES

C.A. Hamer
Extractive Metallurgy Laboratory

D.R. Owens
Mineral Processing Laboratory

June 1988



Project: 50.62.03
Circulating Bed Combustion Systems

MINERAL SCIENCES LABORATORIES
DIVISION REPORT MSL 88-81 (TR)

17pp

MICROMEDIA

SCANNING ELECTRON MICROSCOPIC EXAMINATION OF CHATHAM CIRCULATING FLUIDIZED BED COMBUSTOR ASHES

C.A. Hamer* and D.R. Owens**

ABSTRACT

Ash samples from the Chatham, N.B. 22 MWe circulating fluid bed combustor, heat exchanger, ash cooler, backpass and baghouse were examined by scanning electron microscopy. Large lime particles which are retained in the combustor sulphate to about 50% calcium sulphate. Many particles have a coating of ash and sulphated lime. The smaller particles, in the order 100 micron and smaller, do not appear to be retained in the combustor for sufficient time for them to be utilized to their sulphation potential.

Keywords: Circulating fluidized bed combustion, ash, limestone, sulphation

---

* Research Scientist, ** Research Technologist, Mineral Sciences Laboratories, CANMET, Energy, Mines and Resources Canada

EXAMEN AU MICROSCOPE ÉLECTRONIQUE À BALAYAGE DES CENDRES PROVENANT D'UNE CHAMBRE DE COMBUSTION À LIT FLUIDISÉ CIRCULANT EMPLOYÉE À CHATHAM

C.A. Hamer* et D.R. Owens**

RÉSUMÉ

On a examiné avec un microscope électronique à balayage des échantillons de cendres provenant de la chambre de combustion à lit fluidisé circulant, de 22 MWe, employée à Chatham au Nouveau-Brunswick, ainsi que son échangeur de chaleur, son refroidisseur de cendres, son circuit inverse et sa chambre de dépoussiérage. Les grosses particules de chaux retenues dans la chambre de combustion contiennent des sulfates sous forme de sulfates de calcium dans une proportion pouvant atteindre environ 50 %. De nombreuses particules portent un enduit de cendres et de chaux sulfatée. Les particules plus petites, de l'ordre de 100 microns et moins, ne sont apparemment pas retenues dans la chambre de combustion pendant un temps suffisant pour être utilisées à leur plein potentiel de sulfatation.

Mots-clés : combustion en lit fluidisé circulant, cendres, calcaire; sulfatation

---

*Chercheur scientifique, **Technologue chargé de recherche, Laboratoires des sciences minérales, CANMET, Énergie, Mines et Ressources Canada.

INTRODUCTION

The sulphur dioxide capture with limestone in the Chatham 22 MWe circulating fluidized bed combustor (CFBC) is not as efficient as it should be. The designer of the unit, Lurgi of West Germany, originally claimed that 90% SO_2 capture should be achievable with a Ca/S ratio of 1.25. That claim was considered somewhat optimistic. Laboratory and pilot-scale tests indicated that a Ca/S ratio of 2.5 is more realistic for 90% capture. However, to date Chatham requires a Ca/S ratio of at least 3.5 to attain this target.

In an attempt to understand the cause of the poor sulphur capture, ash samples from several combustion runs in December, 1987 were examined by scanning electron microscope (SEM), X-ray and chemical analysis. The SEM data and their interpretation are presented in this report.

EXPERIMENTAL

Samples

The ash samples came from the Chatham CFBC and were labled: Tests 143, 144, 146 am and 146 pm. Samples were taken from the fluid bed (FB), heat exchanger outlet (HEO), ash cooler (AC), back pass (BP) and baghouse (BH). All were analysed chemically but only seven samples from Tests 144 and 146 were examined by the SEM.

Havelock limestone was used throughout. The Ca/S ratios were 2.57 for Test 143, 3.63 for Test 144 and 2.28 for Test 146 am and pm.

Scanning Electron Microscopy

Samples were examined in the backscattered electron mode of the scanning electron microscope. Qualitative energy-dispersive analysis (EDXA) was used to identify the various phases. Element maps were made for calcium, sulphur, iron, and occasionally silicon. Because of its low atomic number the carbonaceous material is indistinguishable from the mounting medium.

FB The bed material varied in size from 0.1 to 1 mm. The lime particles generally appear to be well sulphated, fig 1. Chemical analysis gives the average calcium utilization, or conversion to sulphate, of 45 - 50%. The sulphur distributions appears quite uniform across the particles. Other particles show a lime core surrounded by a sulphate layer, fig 1 and 2. The cracks in the sulphate layer (fig 2) were probably caused in sample preparation. Many of the sulphated lime and silicate (k) particles are surrounded by a thin layer of coal ash and lime. As the composition of Minto coal ash approaches 50% Fe_2O_3 (hematite) and 30% SiO_2 (silica), the layer shows up as iron on the sulphated lime particles, and as iron and calcium on the silicate particles, fig 1. This effect is more apparent in subsequent photomicrographs.

HEO Samples from Tests 144 1nd 146 were examined. The calcium utilization of this ash is 44 - 50%, Test 144 being the lower. The lime particles are sulphated to varied degrees from very low, as evidenced by the "cal" particle in fig 3, to essentially complete. There are silicate and hematite particles with coatings of a calcium compound, probably calcium sulphate as there is some sulphur present. Some particles have a significant hematite layer, eg lime particle "x" of fig 4. The sulphur concentration in this layer is lower than in the interior of the particle which probably means that the coating is, in fact, a mixture of ash and calcium sulphate. These ash/sulphate layers build up on the older, more rounded and more sulphated particles as compared to the angular shaped, less sulphated lime particles.

AC The one sample examined exhibits a very wide distribution of particle sizes below 200 um, fig 5. The density of particles makes interpretation of the element maps difficult. The calcium utilization is similar to that in the HEO. As the ash cooler is rarely used, the history or residence time of material in this unit is unknown, and the value of examining the sample is questionable.

BP One sample from Test 146pm was examined and is shown in two magnifications as figs 6 and 7. The calcium utilization was 32%. The lower sulphate concentration can be observed by the decreased density of the sulphur map, as compared to, for example, the AC, fig 5. The larger particles of fig 6 tend to be rounded, often exhibiting the hematite coating and are well sulphated. The smaller particles may be more angular and only slightly sulphated, figs 6 and 7. The three particles marked "c" may not even be totally calcined. X-ray analysis confirms the presence of calcium carbonate which thermogravimetric and chemical analysis calculated to be >6%.

BH Two samples are examined at three magnifications. The largest particles are in the 150 um range. The densities of the sulphur maps are less than those of the other ash samples. Calcium utilization of Test 146, represented by figs 8 and 9 is 27 - 32%, whereas Test 144, figs 10 and 11, had a utilization of 23%. Only the larger particles have the ash layer present. There are many particles which appear to be only slightly sulphated. As with the BP sample there is a significant concentration of calcium carbonate, >12% according to the thermogravimetric analysis.

DISCUSSION

These figures, and the analysis, show that large lime particles which stay in the combustor, ie FB and HEO, react with SO_2 to the extent that about 50% of the available calcium forms calcium sulphate. This value is high for a fluid bed and would indicate a very reactive limestone. Many of the smaller particles, which are found in the back pass and baghouse, appear to have passed through the combustor with no recycle. Their time

in the system appears to have been insufficient for them to calcine and sulphate to their potential. Consequently, coarse limestone appears to be more efficient than fine limestone in capturing SO_2. This is contrary to the philosophy of CFBC which is supposed to utilize the increased surface area of small particles to increase sulphur capture.

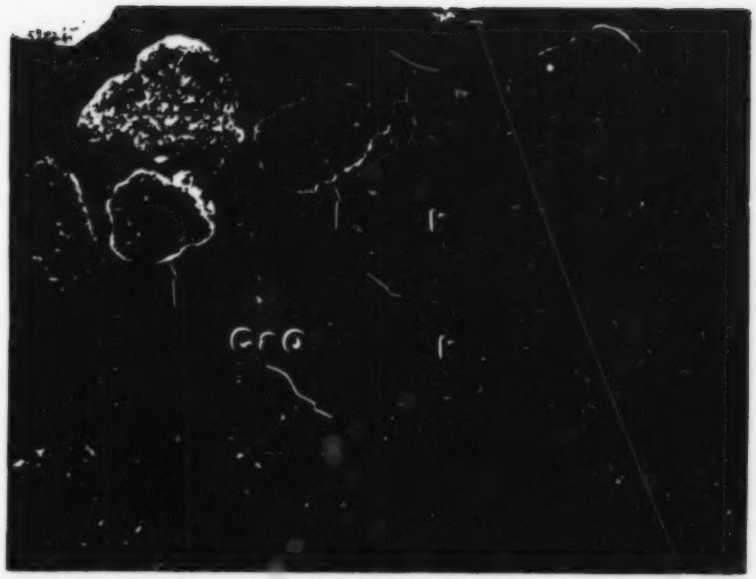
The largest particles leaving the combustor to the back pass and baghouse are about 150 um in size, and a significant portion are in the 100 um range. These large particles indicate that the cyclone is not particularly efficient. Any technique to improve the efficiency of the cyclone, thus reducing the average cut size, would improve the sulphur capture of the combustor.

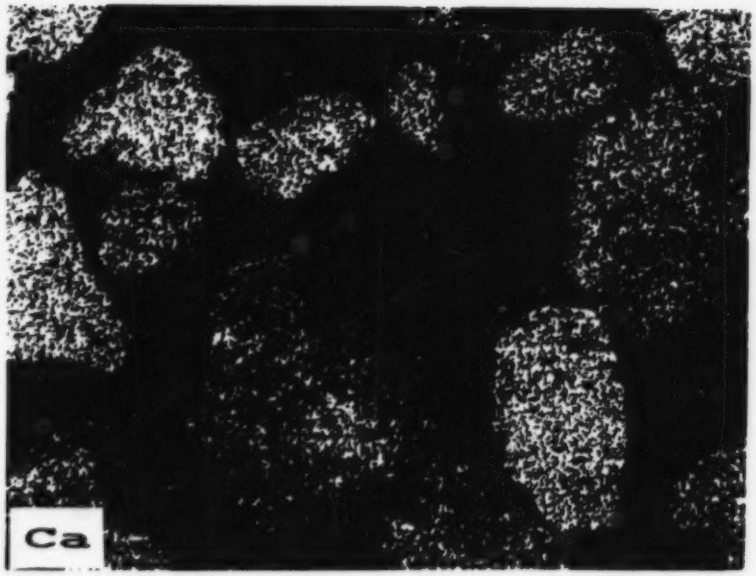
The "age" of the particles in the combustor may be estimated by their shape and the presence of surface coatings. The rounded particles with ash/sulphate layers have probably been in the system much longer than the sharp angular particles with no surrounding layer. Why this ash/sulphated lime coating builds on particles is not known.

A possible explanation for the poor utilization of the finer sized particle limestone may be found in the design of the combustor. The coal is not injected into the combustor but rather falls by gravity down chutes. Limestone is injected but at a location some distance from the coal. Thus the material initially enters relatively close to the combustor walls. Most of the secondary air enters the combustor through the walls near the bottom of the combustor and is used to supplement the primary air. This secondary air enters at low velocity and probably does not penetrate very far into the combustor. Consequently the gas-solids radial mixing within the combustor chamber is probably poor. The situation may exist whereby some of the fine material is carried up the side walls in a dilute stream of secondary air containing a lower than average concentration of SO_2. In this dilute phase there may not be much opportunity for the fine particles to capture SO_2.

CONCLUSIONS

The essential conclusion from this examination is that lime particles which stay in the combustor are utilized to their potential for reacting with SO_2. Since the Chatham system does not appear to be efficient in retaining and recycling particles, in the order of 100 um smaller, these particles do not react to their sulphation potential.





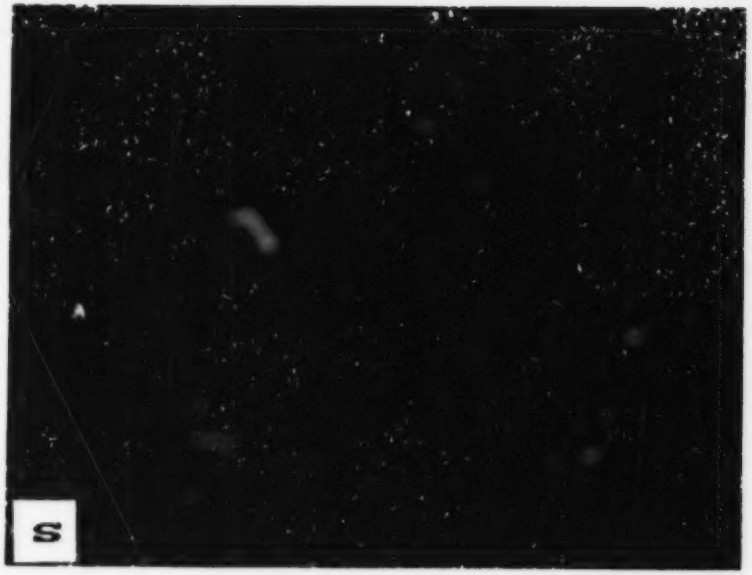
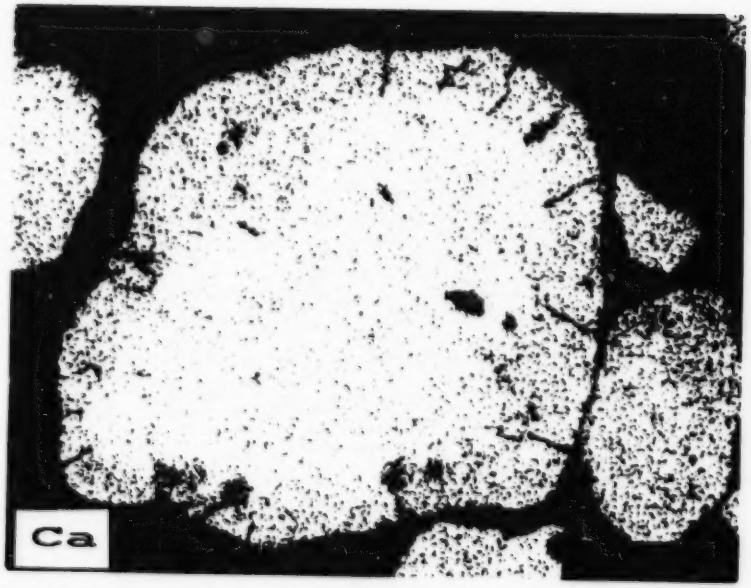


Fig. 1 FB ash, Test 144



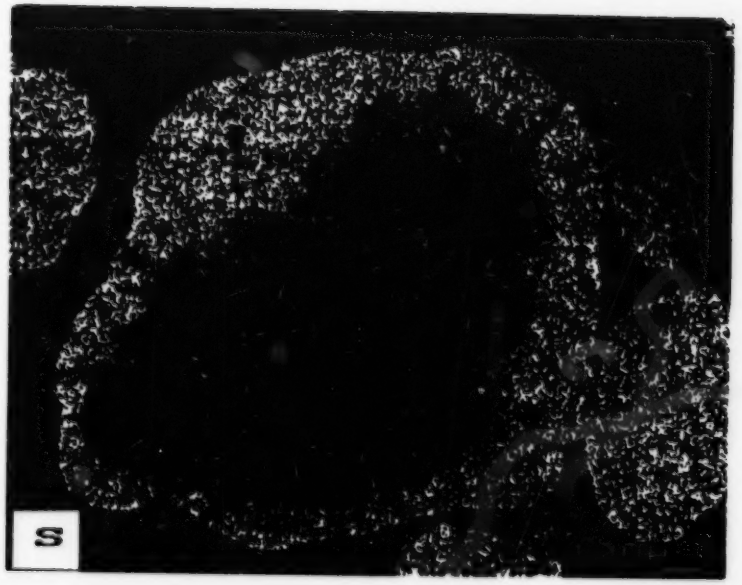


Fig. 2 FB ash, Test 144

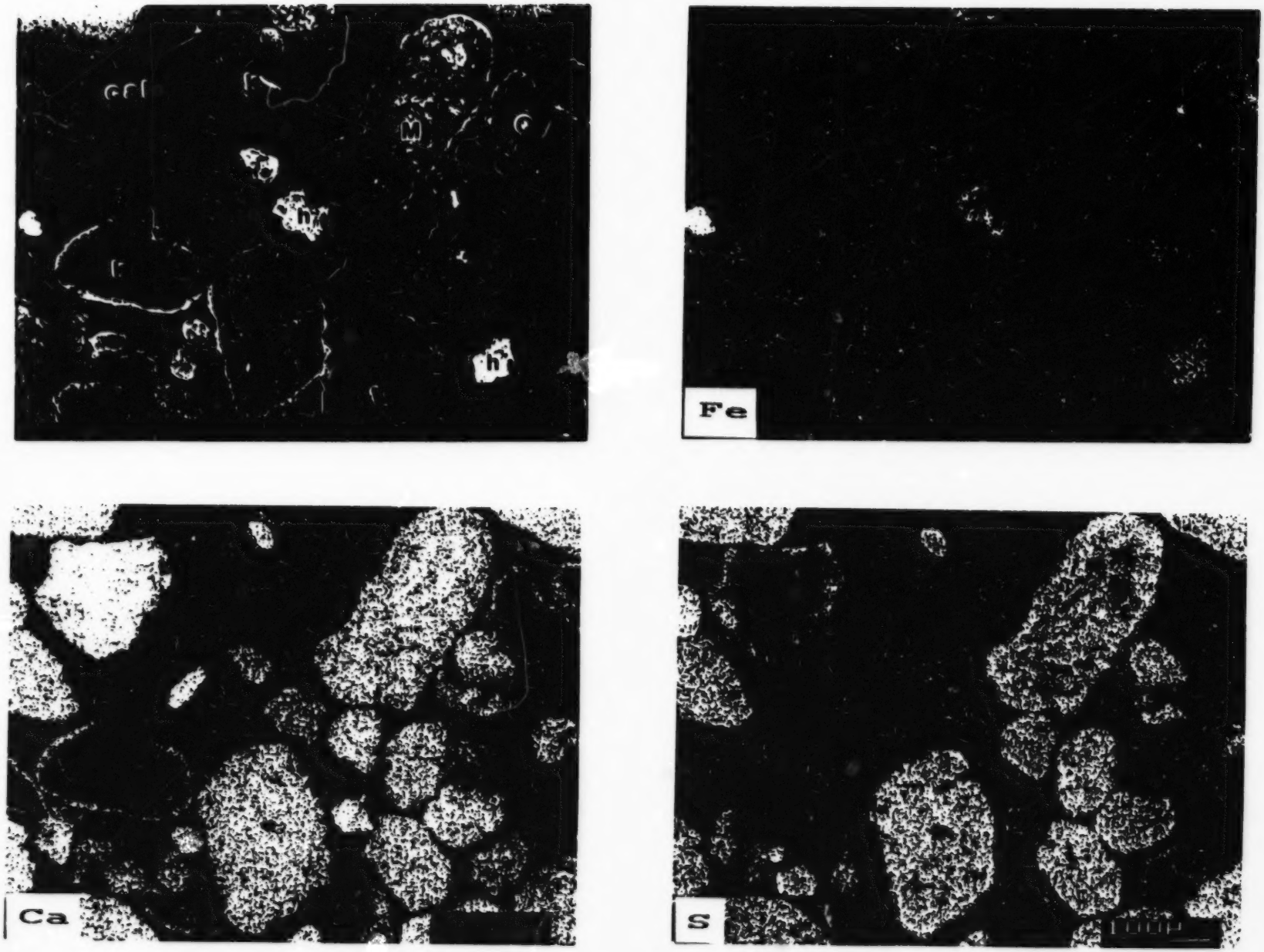


Fig. 3 HEO ash, Test 144

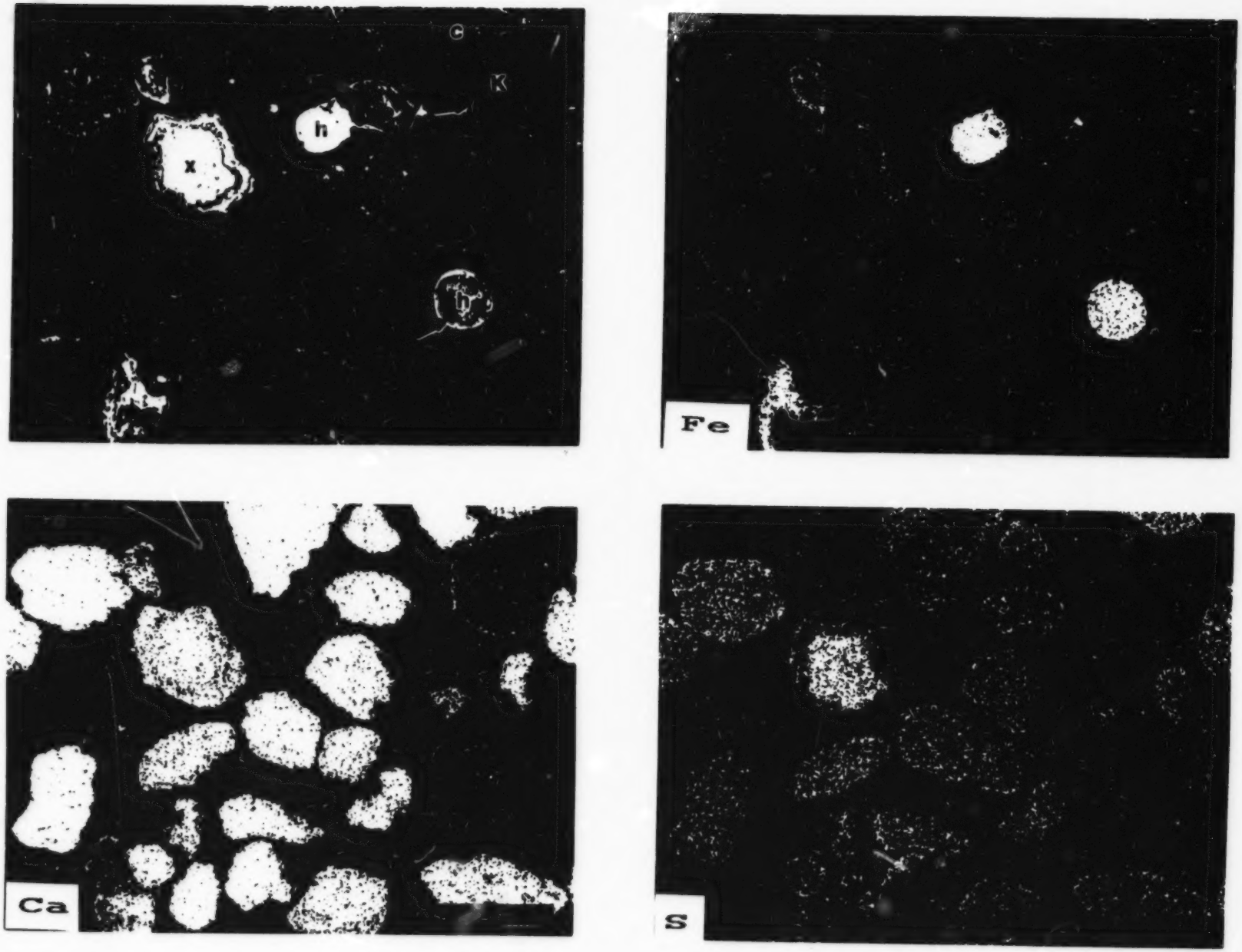
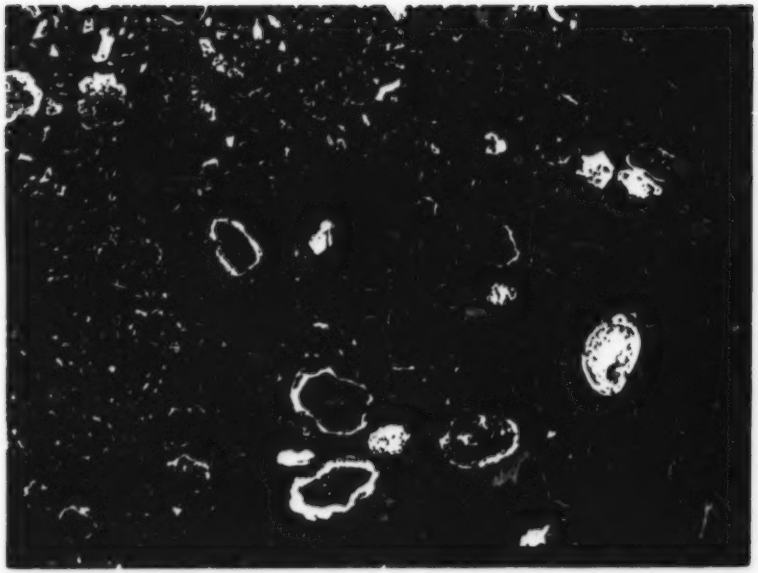
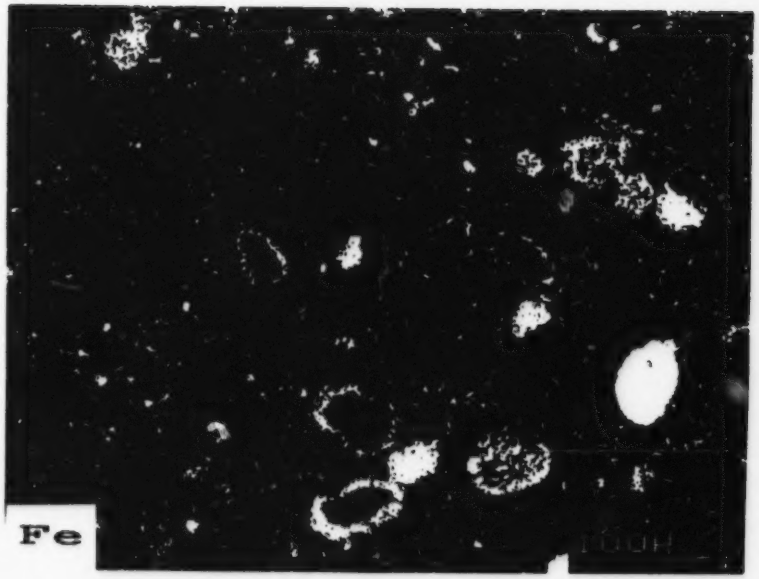


Fig. 4 HEO ash, Test 146pm





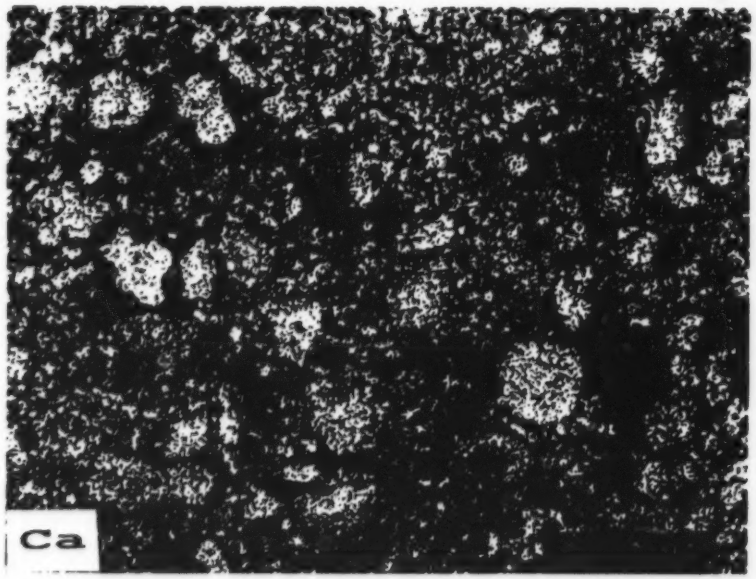
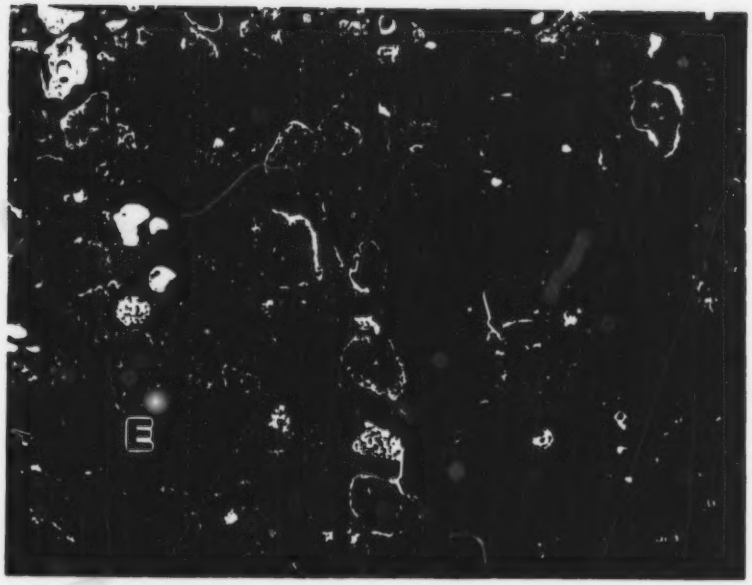
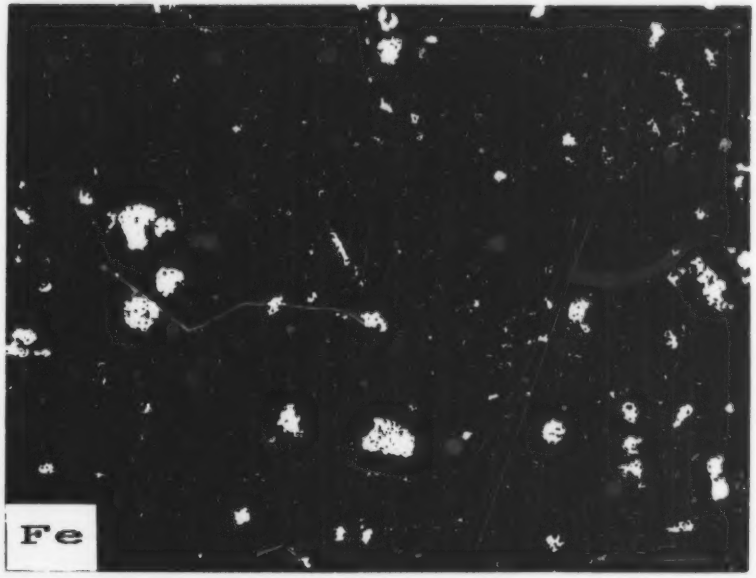


Fig. 5 AC ash, Test 144





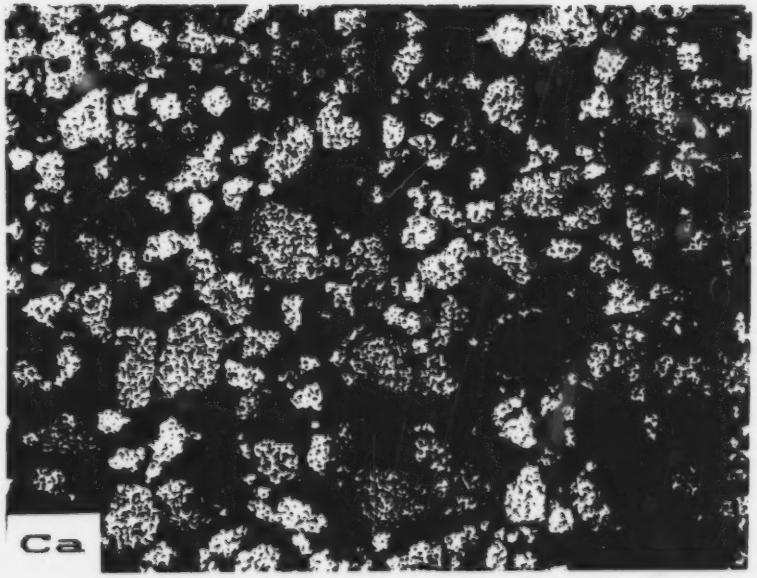
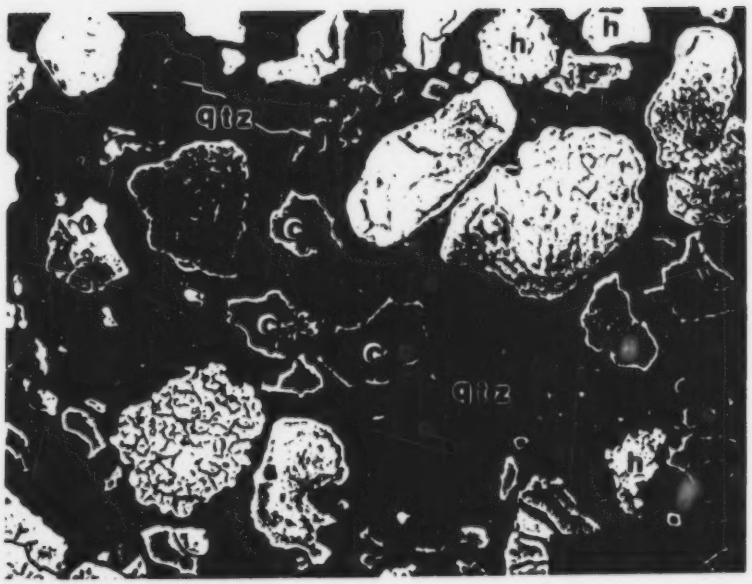
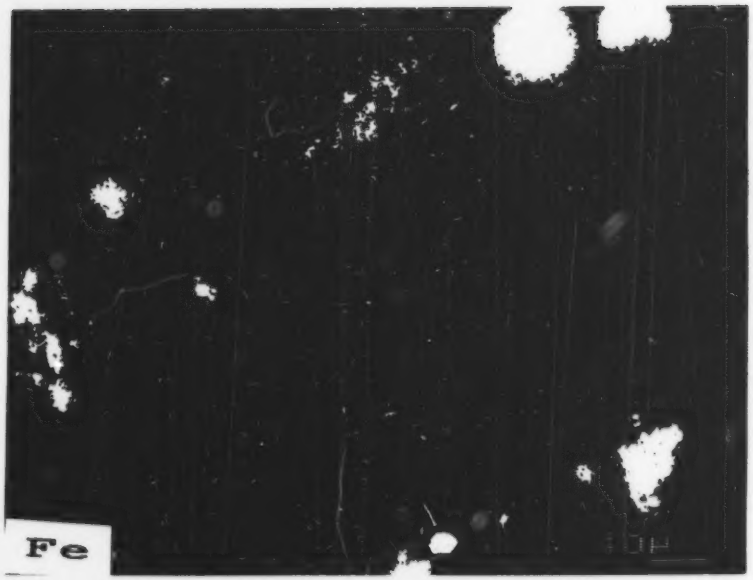


Fig. 6 BP ash, Test 146pm





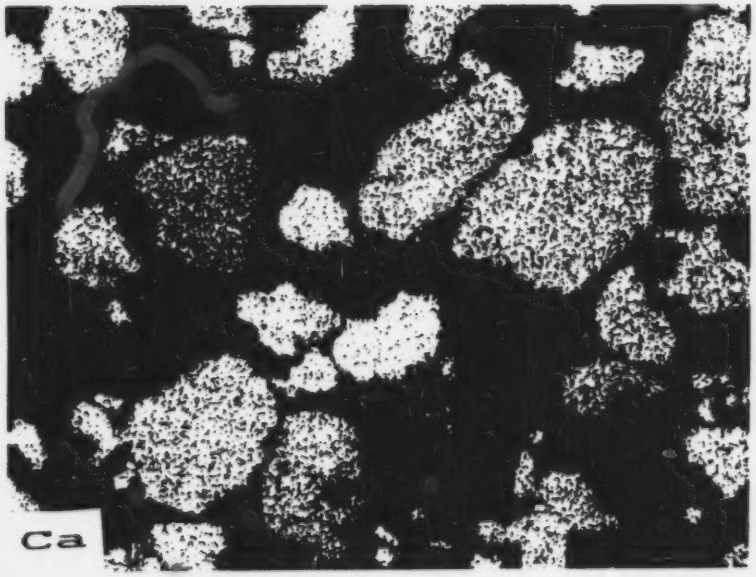


Fig. 7 BP ash, Test 146pm

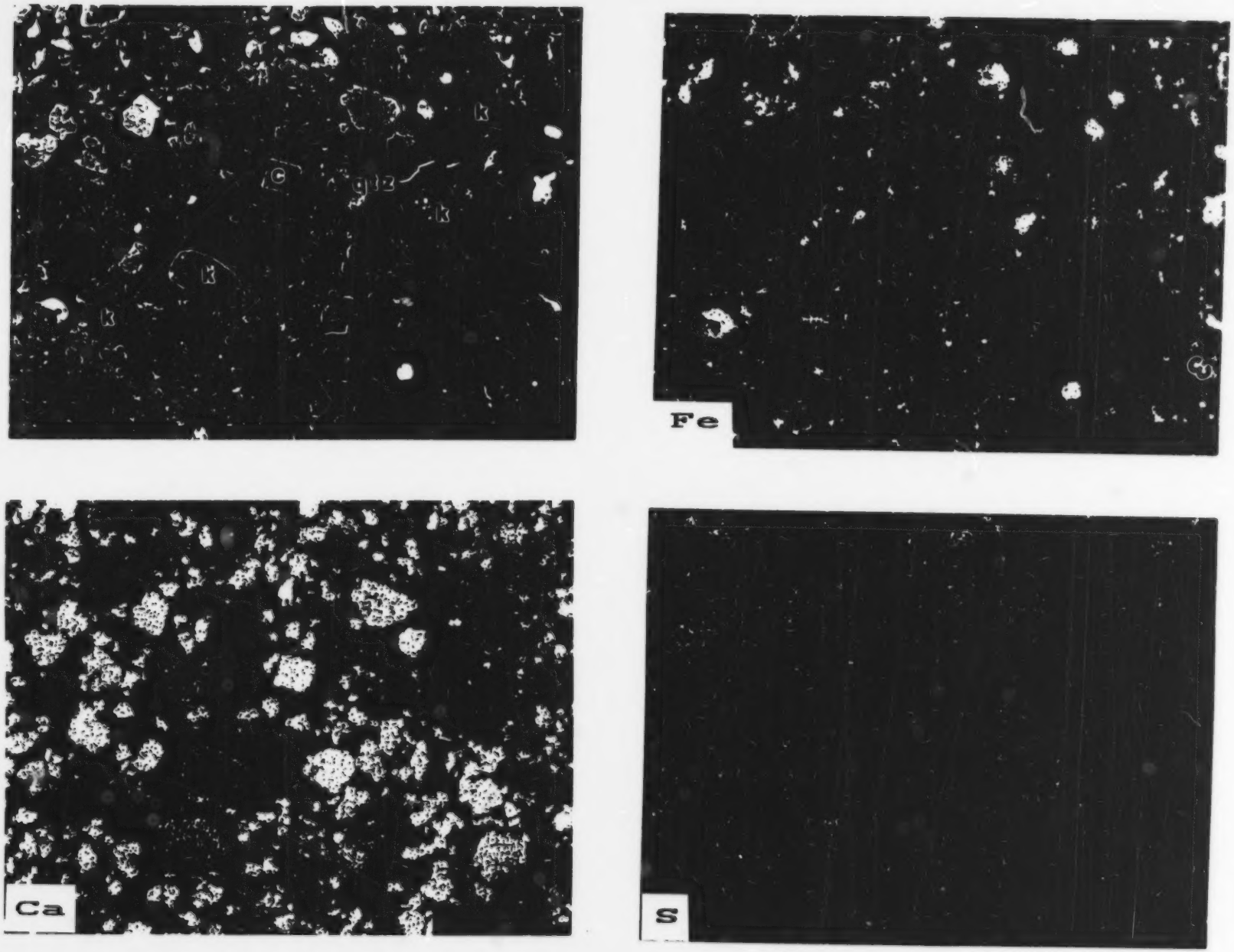
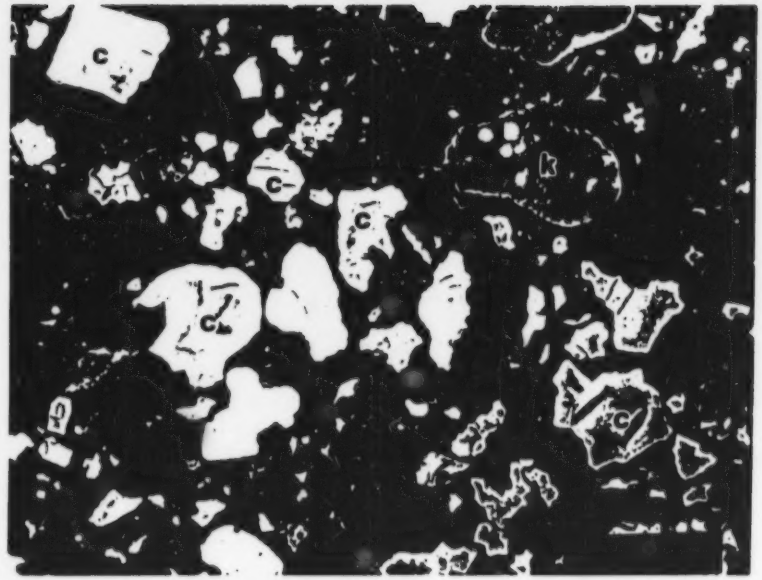
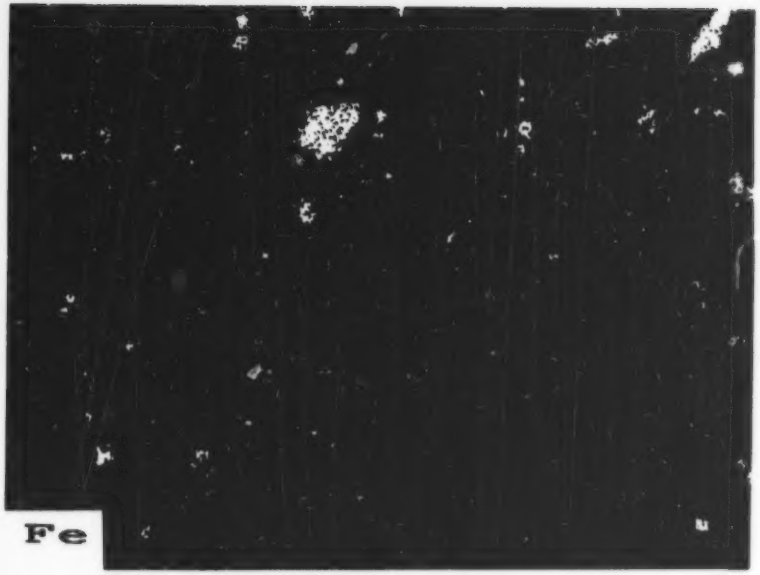


Fig. 8 BH ash, Test 146pm





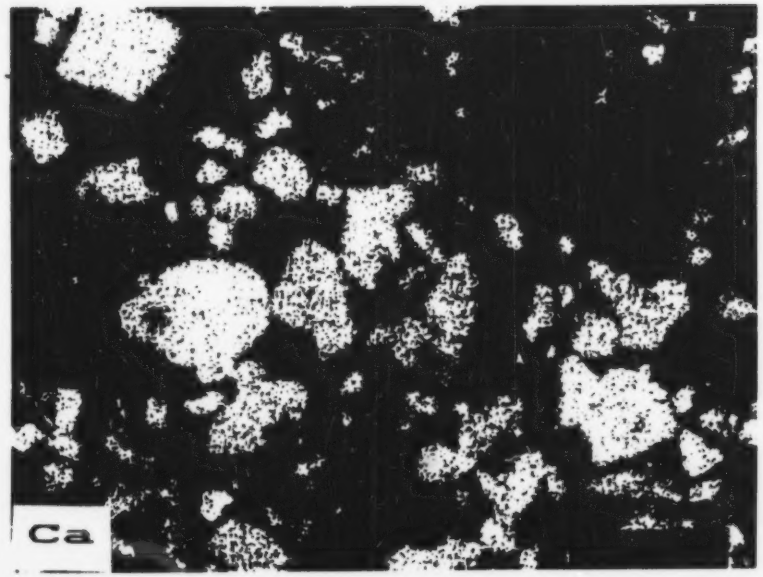
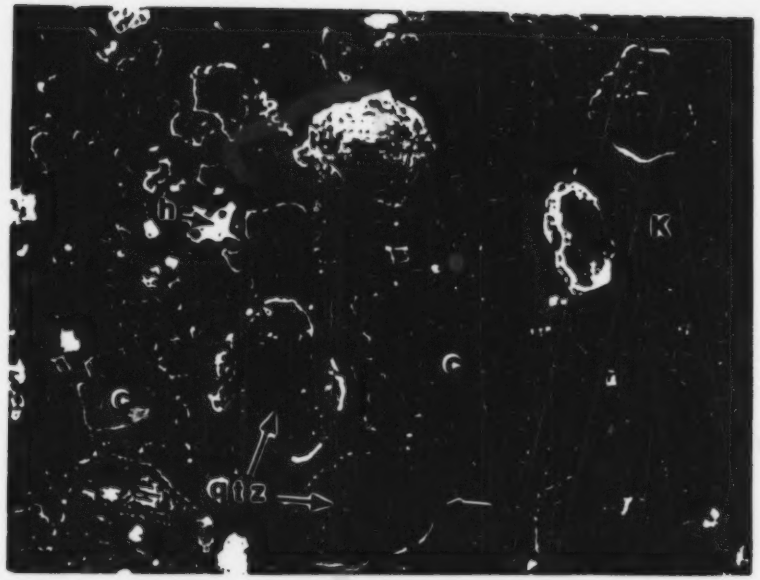
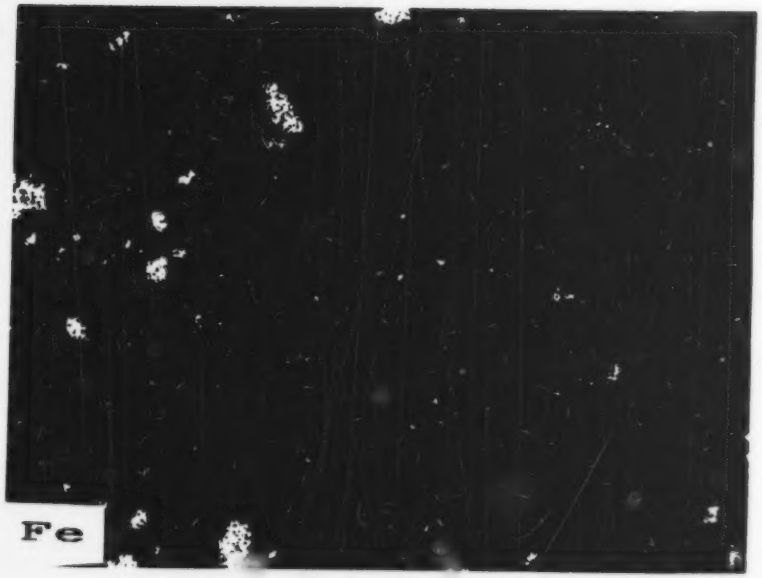
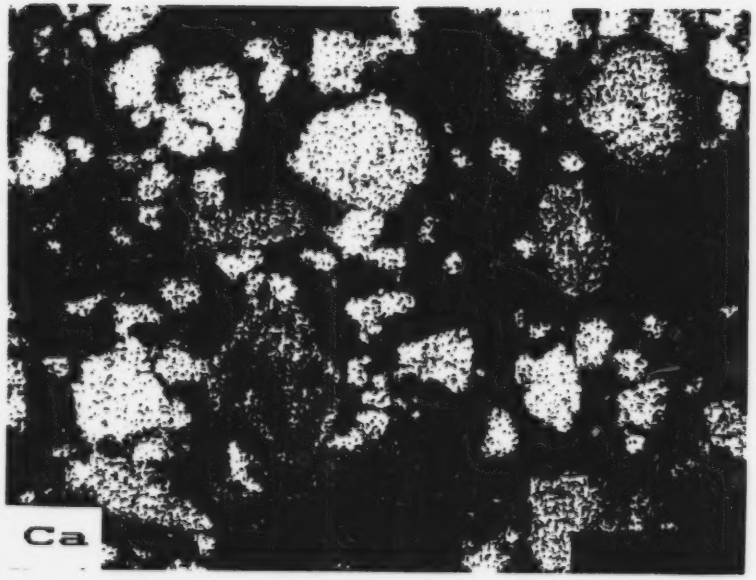


Fig. 9 BH ash, Test 146pm







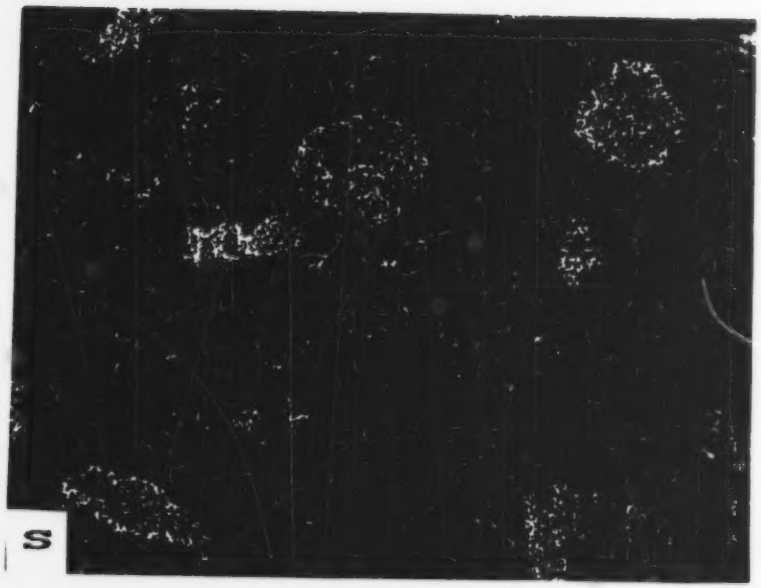
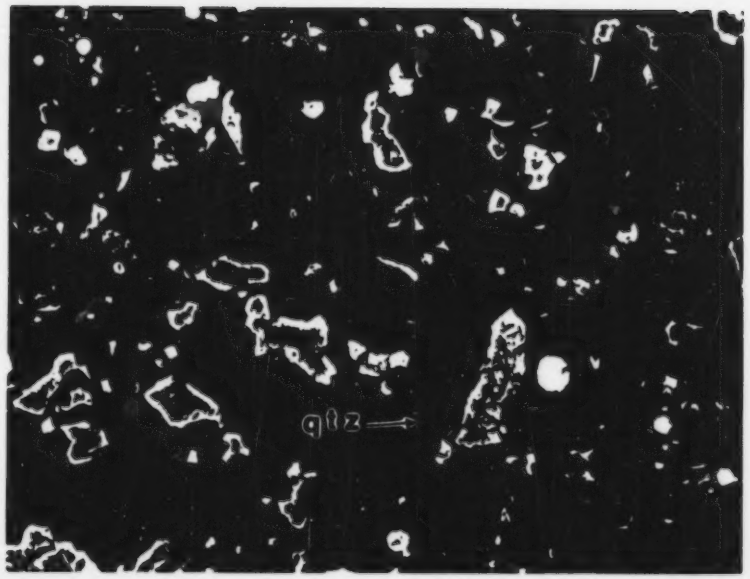
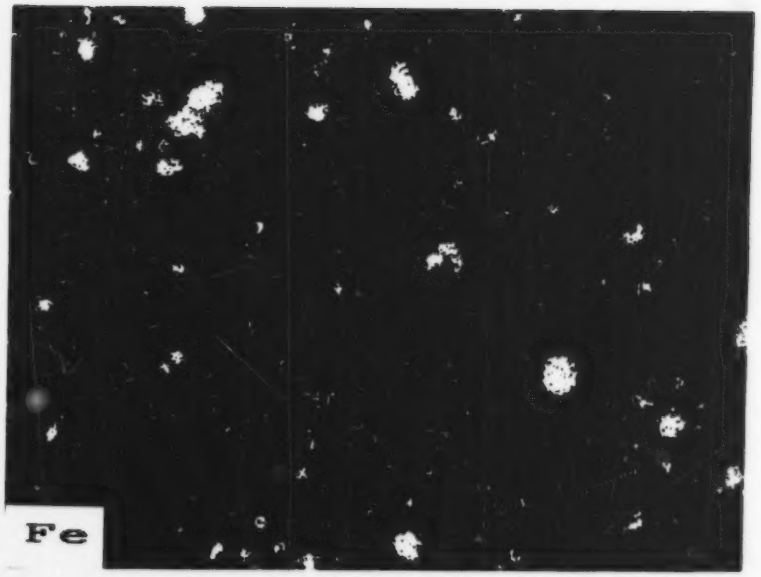


Fig. 10 BH ash, Test 146pm





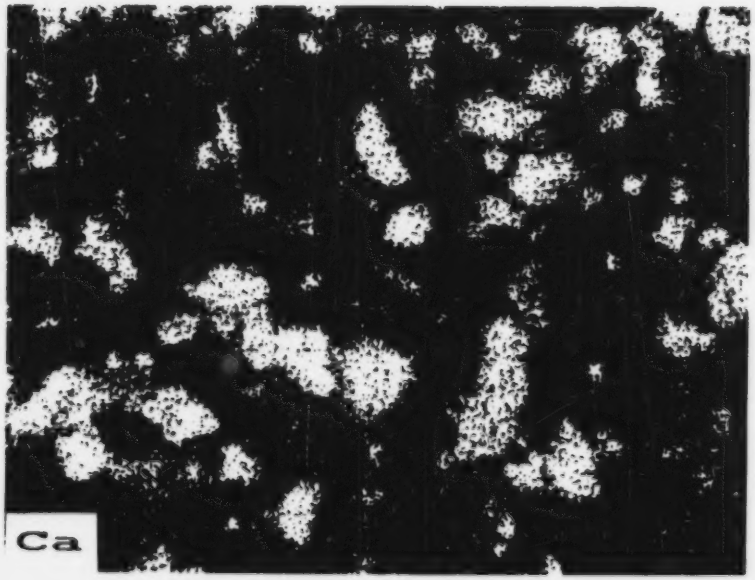


Fig. 11 BH ash, Test 146pm